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## I. SUMMARY

On October 11, 1991, November 25-26, 1991, and February 7, 1992, investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) at the Ohio Department of Agriculture (ODA) laboratory in Reynoldsburg, Ohio. This HHE was performed in response to a confidential employee request concerning microbiological safety in the laboratory. In addition, once the HHE was in progress, ODA management requested an evaluation of noise exposures in the necropsy suite, in the electron microscopy lab, and in a veterinarian's office.

NIOSH investigators administered a questionnaire to employees in Buildings 3, 4, and 6 at the Reynoldsburg labs, performed industrial hygiene measurements during the operation of the Kjeldahl apparatus, evaluated selected laboratory hoods with a thermoanemometer and smoke tubes, and measured noise in the specified areas. The results of air sampling for sulfates, including sulfuric acid, did not reveal concentrations above the limit of detection of the method (2.0 µg/sample). The results of air sampling for sulfur dioxide are not presented in this report due to flaws in the analytical method. The recommendations contained in this report address the control of potential exposures through improved laboratory ventilation. Therefore, no further sampling was performed. Face velocity at the hood (a class II, type B biological safety cabinet) in room 134 in Building 6 was measured at 130 feet per minute (fpm) with the sash open to its usual working position. Smoke tube tests at this hood demonstrated good capture and no spillage of smoke outside of the hood. The average face velocity of the hood (a class I biological safety cabinet) in room 133 in building six was 28 fpm, measured at the opening in the plexiglass cover in front of the hood. While smoke tubes showed capture and no spillage, this face velocity should be compared with design values to determine if it is adequate. Noise measurements were conducted to sample the kinds of noise exposures that the department's veterinarians may encounter during post mortem examinations of animals delivered to the laboratory. Also, NIOSH investigators evaluated exposures to total and respirable particulates generated by electric saws used in necropsy.

The major sources of noise noted in the necropsy laboratory were a Wellsaw and Stryker saw that are used to remove the spinal column, bisect skulls, or open the cranium of animals. Because of the number of animals available to the veterinarians during the visit, the personal noise sampling was limited to the 90 minutes that it took for the veterinarians to complete their work. Both veterinarians wore ear muffs while sawing. Noise levels ranged from 93 to 98 dB(A), but the sawing activities were of short duration, ranging from 12 seconds to 1 minute 37 seconds. Noise from the ventilation system in the necropsy lab, noise in the veterinarian's office, and noise in the electron microscopy lab exceeded recommended Noise Criteria Curves for laboratory facilities where communication is necessary. These criteria have been devised to limit noise to levels where satisfactory speech intelligibility is obtained. The Noise Criteria Curves were derived from data obtained during extensive interviews with personnel in offices, factories, and public places along with simultaneously measured octave-band sound levels. The noise levels in these areas did not approach those associated with the development of noise-induced hearing loss.

Analyses of samples for total particulates collected during necropsy did not reveal concentrations above the limit of detection of the method (LOD: 0.01 mg). The results of air sampling for respirable particulates produced during necropsy were inconclusive. NIOSH investigators did not return to perform additional sampling do to the fact that the results of sampling for total particulates indicated that sampling for respirable particulates would reveal even lower concentrations.

The results of interviews and questionnaires revealed that 91% of the employees in Buildings 3, 4, and 6 participated in the survey. In addition, four maintenance employees requested to be included in the sample. Although the majority of laboratory employees reported ready access to gloves and disposable respirators, there was a great deal of variability in the use of this personal protective equipment. Similarly, there were inconsistencies in the storage locations for food and personal items, the wearing of lab coats or uniforms while eating, and the home laundering of work-specific clothing. Although 35% of the lab workers were aware of the classification of disease organisms according to biosafety level, only one employee reported having received any such training while working at the Reynoldsburg labs, and none of the employees could correctly identify the biosafety level of the organism or disease that they worked with the majority of the time.

On the basis of the data obtained during this investigation, the NIOSH investigators determined that a potential hazard exists for the transmission of infectious organisms to laboratory workers in Building 6, due to the lack of a comprehensive biological safety program at the ODA Reynoldsburg labs. In addition, Building 3 requires extensive renovations to return laboratory ventilation systems to recommended operating parameters. Recommendations to address these problems are presented in Section IX of this report.

Keywords: SIC 8734 (Testing Laboratories), biosafety, agricultural, microbiological and biomedical laboratories, noise.

## II. INTRODUCTION

On October 11, 1991, November 25-26, 1991, and February 7, 1992, NIOSH investigators conducted a Health Hazard Evaluation (HHE) at the Ohio Department of Agriculture (ODA) laboratory facility in Reynoldsburg, Ohio. This HHE was performed in response to a confidential employee request concerning microbiological safety in the laboratory. In addition, at the request of the Building 6 laboratory director, noise exposures were evaluated in the necropsy suite, in the electron microscopy laboratory, and in a veterinarian's office. A letter dated October 29, 1991, reported the results of the October 11 visit. This report presents results and recommendations from all three site visits.

The October 11 investigation consisted of an initial meeting with three representatives from management, two from Ohio Civil Service Employees Association (OCSEA) Local 4550, and two employees, followed by a lengthy walk-through inspection of Buildings 3, 4, and 6. During the walk-through, informal interviews were conducted with several employees, and this information was used to construct the questionnaires that were administered during subsequent visits. An interim letter, dated October 29, 1991, outlined preliminary recommendations for improving the quality of biosafety practices at the Reynoldsburg labs. Suggestions included the implementation of a comprehensive and standardized safety program (as outlined in HHS Publication No. 88-8395, Biosafety in Microbiological and Biomedical Laboratories), immediate repair of damaged asbestos ductwork, and the rapid implementation of planned renovations which would include the replacement of nonfunctional fume hoods in Building 3.[1]

## III. BACKGROUND

Six Divisions are located at the ODA's Reynoldsburg Laboratory Complex. Included in the HHE request were the Animal Industry Division (Building 6) and the Division of Consumer Analytical Laboratories (Buildings 3 and 4). Building 6 receives, records, and routes all mailed and delivered specimens both internally and to other buildings and Divisions. A wide variety of procedures, ranging from gross pathology to avian serology, are performed within Building 6. Employees in this building conduct a variety of diagnostic tests, involving potential exposure to animal tissues, blood, serum, and feces. Diagnostic tests include identification of Brucella, Salmonella, Shigella, Leptospira, and Mycobacterium species, as well as rabies and other viruses that are potentially transmissible to humans in an occupational setting.[2,3] In many cases an individual employee's time is divided between different rooms and different disease organisms. In Building 3, scheduled for major renovation and only partially occupied at the time of the site visits, feed and fertilizer analyses are conducted. In Building 4 general chemical and microbiological analyses on a variety of samples, including milk, meat, feeds, and fertilizers, are performed. Pesticide formulation and residue analyses are also done in this building.

## IV. MEDICAL EVALUATION

### Methods

Questionnaires addressing workplace exposure, work practices, and general health (including presence of chronic diseases such as diabetes, and occurrence of

gastrointestinal events such as diarrhea and constipation) were administered on a voluntary basis to all employees in Buildings 3, 4, and 6, as well as to maintenance staff. These questionnaires were administered by NIOSH investigators on November 25 and 26, 1991. Employees unavailable on those dates were contacted on February 7, 1992. Fifty-one (91%) of the 56 laboratory workers, and 4 self-selected maintenance workers participated. Respondents were 62% female, ranged in age from 24 to 62 years (mean=42 years), and had worked at the Reynoldsburg labs for a mean of 11 years (range= 2 to 26 years).

## V. INDUSTRIAL HYGIENE EVALUATION

### Materials and Methods

On November 25, 1991, four personal breathing zone (PBZ) and two general area (GA) air samples were collected for total sulfates and sulfites, sulfur dioxide and sulfur trioxide at the Kjeldahl apparatus. Two PBZ and one GA sample were collected in the morning. In the afternoon, two additional PBZ samples and one additional GA sample were collected. Personal samples were collected in the breathing zones of the flame photometrist and the Kjeldahl operator, while the area sample was located just outside the sash of the hood enclosing the apparatus. Samples were collected and analyzed according to NIOSH Method 6004.[4] Samples were collected using two filters in series connected via Tygon tubing to a personal sampling pump operating at a flow rate of 1.0 liter per minute (lpm). The first filter, a 37 millimeter (mm) diameter, 0.8 micrometer (µm) pore size, mixed cellulose ester filter is used to collect sulfuric acid, sulfate salts and sulfite salts, which are quantitated as total particulate sulfate and sulfite. A second filter, identical to the first, except that it is treated prior to sample collection with a solution of potassium hydroxide and glycerol, collects gaseous sulfates. All samples were analyzed by ion chromatography.

On February 7, 1992, two PBZ samples for total particulates and two PBZ samples for respirable particulates were collected in the necropsy suite while two veterinarians performed dissections. One sample of each type was collected in the breathing zone of each veterinarian. Air samples for total particulates were collected using tared 37 mm diameter, 5 µm pore size polyvinyl chloride (PVC) filters connected via Tygon tubing to personal sampling pumps operating at 2.0 lpm. Filters were weighed according to NIOSH Method 0500, with modifications: 1) The filters are stored in an environmentally controlled room (21$\pm$3 °C and 40$\pm$3% relative humidity) and are subjected to these conditions for a long time for stabilization.[4] This reduces the stabilization time between tare weighings from 8-16 hours to 5-10 minutes. 2) The filters and backup pads are not vacuum desiccated. Respirable particulates were collected using four-stage Marple cascade impactors connected via Tygon tubing to personal sampling pumps operating at a flow rate of 2.0 lpm. Cascade impactors contain a number of stages in series with graduated nozzle velocities and impaction distances to effect a progressive separation of smaller and smaller particles as the aerosol travels through the unit. Impactors operate on the principle that when a moving stream is deflected from a straight course, the inertia of some of the particles in the stream will prevent them from following the airstream, and thus diverted, they will strike the deflecting obstacle. Particles were collected on tared PVC filters, which were then re-weighed in accordance with NIOSH Method 0500.[4]

Noise measurements collected in the necropsy suite, electron microscopy lab and a veterinarian's office on November 25, 1991, were made with a Gen Rad model 1982 sound level meter with an octave band filter. The instrument was pre- and post-calibrated according to the manufacturer's instructions. Octave band measurements at consecutive center frequencies of 31.5 Hertz (Hz) to 16 kilohertz (Khz) along with A-weighted and C-weighted sound level measurements were made while the ventilation systems were operating in the necropsy suite and veterinarian's office, and while the vacuum pump was running in the electron microscopy lab.

The noise dosimeters used in the February 7, 1992, survey were Metrosonics Model dB301/26 Metrologgers, a small noise level recording device which is worn on the waist of the employee with a 1/4 inch microphone attached to the worker's shirt collar, or the shoulder area if the shirt has no collar. This dosimeter is designed to measure noise in decibels, A-weighted levels (dB[A]) four times per second. The noise measurements are integrated according to the Occupational Safety and Health Administration (OSHA) noise regulation (see Evaluation Criteria section of this report) for an entire minute and stored separately in the Metrologger for later analysis and final storage. Each dosimeter was calibrated according to the manufacturer's instructions before being placed on the worker. After the recording period was completed, the dosimeter was removed from the worker and placed in the standby mode of operation. The data were later transferred to a Metrosonics Model dt-390 Metroreader/Data Collector following the noise sampling. Prior to turning off the dosimeter, it was again calibrated to assure that the device had not changed during the sampling period. The dosimeter information was finally transferred to a personal computer with supporting Metrosonics Metrosoft computer software for permanent data storage and later analysis.

Additional area noise samples were made on February 7, 1992, with a Larson-Davis Laboratories Model 800B Precision Integrating Sound Level Meter. Octave band measurements at consecutive center frequencies of 31.5 Hertz (Hz) to 16 kilohertz (Khz) along with A-weighted and C-weighted scales were made in the center of the laboratory while the ventilation system was operating. Also, A-weighted measurements were made with the meter in the integration mode for each of the post mortem operations that resulted in noise exposures to the veterinarians. Octave measurements were made with the sound level meter integrating the sound energy over a 1-minute period with a 3 dB exchange rate.

## VI. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to ten hours a day, forty hours a week for a working lifetime without experiencing adverse health effects. However, it is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These

combined effects are often not considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are the following: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs), and 3) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs).[5,6,7] The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; in contrast, the NIOSH-recommended exposure limits are primarily based upon the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that employers are legally required to meet those levels specified by an OSHA PEL.

A time-weighted average exposure level (TWA) refers to the average airborne concentration of a substance during a normal eight- to ten-hour workday. Some substances have recommended short-term exposure limits (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from brief high exposures.

A. Noise

Occupational deafness was first documented among metalworkers in the sixteenth century.[8] Since then, it has been shown that workers have experienced excessive hearing loss in many occupations associated with noise. Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[9]

While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[10]

The OSHA standard for occupational exposure to noise (29 CFR 1910.95) specifies a maximum PEL of 90 dB(A)-slow response for a duration of 8 hours per day.[11] The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship. This means that in order for a person to be exposed to noise levels of 95 dB(A), the amount of time allowed at this exposure

level must be cut in half in order to be within OSHA's PEL. Conversely, a person exposed to 85 dB(A) is allowed twice as much time at this level (16 hours) and is within his daily PEL. Both NIOSH, in its Criteria for a Recommended Standard, and the ACGIH, in their TLVs, propose an exposure limit of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard.[12,13] Both of these latter two criteria also use a 5 dB time/intensity trading relationship in calculating exposure limits.

Time-weighted average (TWA) noise limits as a function of exposure duration are shown below:

| Duration of Exposure | Sound Level (dB(A)) | |
|---|---|---|
| (hrs/day) | NIOSH/ACGIH | OSHA |
| 16 | 80 | 85 |
| 8 | 85 | 90 |
| 4 | 90 | 95 |
| 2 | 95 | 100 |
| 1 | 100 | 105 |
| 1/2 | 105 | 110 |
| 1/4 | 110 | 115 |
| 1/8 | 115 | * |
| | ** | |

*No exposure to continuous or intermittent noise in excess of 115 dB(A).
**Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

The OSHA regulation has an additional action level (AL) of 85 dB(A) which stipulates that an employer shall administer a continuing, effective hearing conservation program when the TWA value exceeds the AL. The program must include monitoring, employee notification, observation, an audiometric testing program, hearing protectors, training programs, and recordkeeping requirements. All of these stipulations are included in 29 CFR 1910.95, paragraphs (c) through (o). The OSHA noise standard also states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels. Also, a continuing, effective hearing conservation program shall be implemented.

Noise produced at intensities less than is necessary to cause loss of hearing can be disruptive in the workplace. Interference with speech and disruption of office activities are possible results of unwanted noise. The results from the noise can be

deterrents to the efficiency and productivity of the office staff and can be detrimental to the occupants' comfort and sense of well-being. Noise criteria for enclosed spaces have been devised to limit noise to levels where satisfactory speech intelligibility is obtained.[14] These criteria were devised through the use of extensive interviews with personnel in offices, factories, and public places along with simultaneously measured octave-band sound levels. The interviews consistently showed that people rated noise as troublesome when its speech interference level is high enough to make voice communication difficult.

B. Sulfur Dioxide

Although the Kjeldahl apparatus produces sulfur trioxide ($SO_3$), any $SO_3$ that escapes from the process will be oxidized rapidly to sulfur dioxide. Sulfur dioxide ($SO_2$) is a colorless, water-soluble gas which is severely irritating to the eyes, mucous membranes, and skin. On contact with moist membranes, it rapidly forms sulfurous acid ($H_2SO_3$). Acute exposures to $SO_2$ above 10 parts per million (ppm) are irritating to the eyes, nose, and throat, and can cause choking, coughing, and increased mucous secretion. Repeated exposures to 10 ppm have caused nosebleeds among exposed workers.[15] Acute inhalation of large amounts of sulfur dioxide can result in death from asphyxia.[16] Bronchial asthma can also result following acute exposure to $SO_2$.[17]

Individuals have varying sensitivity to the broncho-constricting effects of $SO_2$. Experimental studies on healthy human volunteers at rest exposed to 1 ppm $SO_2$ have shown that airway resistance is generally not affected after short-term exposure, but decreases in forced expiratory airflow have been found in some individuals after prolonged exposure.[18] Deep breathing has been found to increase airway resistance at exposures of 1 ppm.[19] At exposures less than 1 ppm, persons with mild asthma exhibited increased airway resistance during moderately heavy exercise.[20]

In 1974, NIOSH recommended that occupational exposures to $SO_2$ not exceed 2 ppm for up to a 10-hour TWA exposure over a 40-hour workweek.[17] On the basis of the results of four other epidemiological studies, available by 1977, NIOSH reduced its recommended exposure limit from 2 ppm to 0.5 ppm for a 10-hour TWA.[21]

The OSHA PEL for $SO_2$, revised in 1989, is 2 ppm for an 8-hour TWA. OSHA has also established a 15-minute STEL of 5 ppm.[6]

C. Sulfuric Acid

Sulfuric acid is a severe irritant of the respiratory tract, eyes, and skin.[22] In a recent study of 248 lead-acid battery workers, no significant association was found between exposures of up to 0.42 $mg/m^3$ and symptoms of cough, phlegm, dyspnea, and wheezing.[23] However, the forced vital capacity (a measure of lung function) in the group of workers with the highest exposure was lower than those in the lower exposure group. Repeated exposure of workers has reportedly

resulted in chronic conjunctivitis, tracheobronchitis, stomatitis, and dermatitis (inflammation of the eyes, air passages, mouth, and skin, respectively).[24]

The NIOSH REL, OSHA PEL, and ACGIH TLV for sulfuric acid are 1 mg/m$^3$.[5,6,7] Additionally, ACGIH has recommended a STEL of 3 mg/m$^3$.[7]

D. Total and Respirable Particulates Produced at Necropsy

Three potential routes of exposure to infectious agents have been noted during necropsy: Percutaneous exposure, e.g. injury by contaminated sharps, such as needles, scalpels, or bone spicules; mucous membrane and open wound exposure, e.g. contamination of conjunctivae, nose, mouth, abrasions, or lacerations by blood or body fluids; or inhalation exposure to aerosols produced during evisceration, washing of organs, squeezing and manipulation of tissues, and use of high speed oscillating saws to cut bone and cartilage.[25] The most frequent cause of laboratory-associated infections is probably the inhalation of an infectious aerosol.[26] Two recent studies have investigated the role of surgical power tools in the production of aerosols.[25,27] One of these, a study of aerosols generated at human autopsy, noted a peak concentration of respirable particles of 5700 particles/cc, when a Stryker saw was used to remove the skull cap of a young male.[25] All of the particles captured in the saw operator's breathing zone were respirable (<10 μm), with a mean diameter of 0.37 μm. The other study, where a Stryker saw was again among the instruments evaluated, noted that blood was detected among the aerosols generated, and that most of the particles collected were less than 5 μm.[27] In addition, data collected at animal necropsy by the U.S. Army at Fort Detrick, MD, noted that 30 test organisms were recovered from the air during the autopsy of an animal dissected immediately after the intraperitoneal injection of 10 ml of a culture of the test organism.[28] While these studies indicate that the potential is present for the production of infectious aerosols during necropsy, standards specific to the evaluation of infectious aerosols do not exist.

E. Laboratory Ventilation

A laboratory requires regulation of temperature, humidity, air pressure, air motion, air cleanliness, light, sound, and vibration.[29] Most aging laboratory facilities (greater than fifteen years old) require extensive renovations to their heating, ventilation, and air-conditioning (HVAC) systems.[29] A recent survey found that 43% of the research facilities in the United States are more than 20 years old and that they lack mechanical services to support current research needs.[30] There are several sources of information on the design and evaluation of laboratory ventilation systems.[1,29,31-34]

The OSHA standard for Occupational Exposure to Chemical Hazards in Laboratories defines a laboratory-type hood, and mandates that the chemical hygiene plan include a requirement that fume hoods and other protective equipment are functioning properly and that this plan specify measures that shall be taken to ensure proper and adequate performance of such equipment.[35] Section C of Appendix A of this standard provides information on the design and performance requirements of laboratory ventilation:

1. The laboratory facility should have an appropriate general ventilation system with air intakes and exhausts located so as to avoid intake of contaminated air; the facility should have laboratory hoods and sinks.

2. The general laboratory ventilation system should provide a source of air for breathing and for input to local exhaust ventilation devices; it should not be relied on for protection from toxic substances released into the laboratory. It should ensure that laboratory air is continuously replaced, preventing increase of air concentrations of toxic substances during the working day, and should direct airflow into the laboratory from non-laboratory areas and out to the exterior of the building.

3. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every two workers if they spend most of their time working with chemicals; each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use. If this is not possible, work with substances of unknown toxicity should be avoided or other types of local ventilation should be provided.

4. Ventilated storage cabinets, canopy hoods, snorkels, etc., should be provided as needed. Each canopy hood and snorkel should have a separate exhaust duct.

5. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system. Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of an electrical failure.

6. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate.

7. Four to twelve room air changes per hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control.

8. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas; airflow into and within the hood should not be excessively turbulent; hood face velocity should be adequate (typically 60-100 linear feet per minute).

9. Quality and quantity of ventilation should be evaluated on installation, regularly monitored (at least every three months), and reevaluated whenever a change in local ventilation devices is made.

The testing and evaluation of laboratory hoods is described in detail in ASHRAE standard ANSI/ASHRAE 110-1985, Method of Testing Performance of Laboratory Fume Hoods.[36]

Finally, while the OSHA bloodborne pathogens standard applies only to exposures to human blood, its components, and products made with human blood, the standard requires the certification of biological safety cabinets when they are installed, whenever they are moved, and at least annually.[37]

## VII. RESULTS AND DISCUSSION

### A. Medical

Results from the work practices portion of the survey are given in Table 1. Almost all employees reported a variety of job tasks involving different room locations, differing technical procedures, and different organisms. All laboratory employees had ready access to disposable gloves, and 91% wore gloves at some point in the work day. However, 49% of those that did wear gloves only used one pair daily. Ninety-five per cent of the lab workers felt that they had access to disposable respirators and 54% reported using them on a daily basis. During the initial walk-through inspection, only one worker was observed wearing a disposable respirator, and none were seen using eye protection, although one-third of the surveyed workers reported using eye protection.

During the initial walk-through inspection, several employees voiced concern about a perceived excess of gastrointestinal disease among employees at the Reynoldsburg lab complex. In response to these concerns, several questions addressing incidence and prevalence of gastrointestinal symptoms were included in the health status portion of the questionnaire. Eleven (31%) of the 36 workers in Building 6 reported experiencing an episode of diarrhea (defined as 3 or more loose stools in 24 hours) in the past twelve months, as compared to three (25%) of the 12 workers in Building 4. No workers in Building 3 reported having had such episodes in the previous twelve months. Only workers in Building 6 reported experiencing 3 or more such episodes in the past year.

Twenty-three (42%) of the 55 employees had, at some point, contacted a physician for signs or symptoms related to the gastrointestinal tract. Seven (30%) had made such medical contact within the past 24 months. Nine (16%) of the 55 employees reported frequent abdominal cramping, one (2%) reported frequent vomiting, and one (2%) reported unexplained weight loss in the past six months.

### B. Industrial Hygiene

#### 1. Noise

The noise dosimeters were placed on the two veterinarians within a minute of each other. Thus, the results from each can be directly compared to show the influence of one's activities on the noise exposure of the other. The noise time lines are shown in Figures 1 and 2. The high peaks seen in the two graphs seem to coincide with each other fairly often. These peaks are the result of the use of the saws in the post mortem operations. Of course, the peaks are greater when the veterinarian is actually using the saw. The relatively low noise exposures seen in Veterinarian #1's record from 15 minutes until 30 minutes is the result of this veterinarian leaving the laboratory. Overall, each

veterinarian had the same noise exposure of 81 dB(A) for the 90-minute period. The peaks shown in the graphs had a maximum value of 99 dB(A) for Veterinarian #1 and 98 dB(A) for Veterinarian #2.

Individual sawing activities were measured with a sound level meter. Each measurement yields an equivalent level ($L_{eq}$), a high and low root-mean-square level encountered during the measurement period, and the elapsed time of the measurement. These values are shown in Table 2.

Each of the sawing activities was relatively short in duration, ranging from 12 seconds to 1 minute, 37 seconds. The majority of the post mortem work was done with knives. The noise levels ranged from 93 dB(A) to 98 dB(A). The loudest measurement recorded was for the midline split of the cow skull. This was done with the skull on a metal table in the laboratory. The sawing caused the skull to vibrate against the metal table, resulting in additional noise from the skull rattling on the table.

The noise spectrum from the ventilation system is presented in Figure 3. The measurements were made in the laboratory while no other noisy activities were taking place. Included in the figure are the Noise Criteria (NC) Curves for enclosed spaces that have been developed to evaluate noise conditions in rooms that will allow satisfactory speech intelligibility.[14] It can be seen in the figure that the ventilation system noise slightly exceeds the NC-65 curve at 250, 500, 1000, and 2000 Hz octave bands, sounds which are included in the Speech Interference Level (SIL) criteria used to evaluate the effects of noise on speech intelligibility.[37] Areas which falls into the NC criteria of NC-50 to NC-60 have been designated as kitchens, laundries, shops, garages, machinery spaces, power plants, or mechanical equipment control rooms where only minimum levels of acceptable speech communication are required and there is no risk of hearing damage. Areas with NC curves ranging from 55 to 70 are classified as work spaces where speech or telephone communication is not required, but where there must be no risk of hearing damage.[38]

The noise spectrum measured in the veterinarian's office and the electron microscopy lab are presented in Figures 4 and 5. Noise measurements in the veterinarian's office were made while the office was unoccupied. The ventilation system was the only source of noise in the office while measurements were made. As shown in Figure 4, noise in the veterinarian's office exceeded the NC-60 curve at 125 Hz and exceeds the NC-55 curve at 250 Hz. Private offices, small conference rooms, libraries, classrooms, and similar locations should be within the NC-30 to NC-35 noise criteria for good listening conditions. Noise in this office could be controlled through the installation of a noise-reducing diffuser in place of the air-supply diffuser currently installed in the office. Figure 5 provides the results of noise measurements conducted in the electron microscopy laboratory. The NC-55 curve is exceeded at 250 and 4000 Hz, the NC-60 curve is exceeded at 1000 and 2000 Hz, and the NC-65 curve is exceeded at 500 Hz. For moderately fair listening conditions, laboratory work spaces are classified in the NC-40 to NC-50 range. The miscroscope's vacuum pump was the primary noise source in the lab. The A-weighted sound pressure level measured with this pump off

was 48 dB(A); with the pump on, the level increased to 66 dB(A). Enclosure or relocation of the pump outside of the laboratory would reduce or eliminate this noise.

2. Particulates Produced at Necropsy

Analysis of samples for total particulate collected during necropsy did not reveal concentrations above the limit of detection (LOD: 0.01 mg/filter) of the method. Analysis of samples for respirable particulates was inconclusive. However, since the results for total particulates were less than the LOD, one would not expect to find elevated concentrations of the respirable portion of the particulates present. The Wellsaw, which was used for the majority of work requiring a saw, appeared to direct the majority of the particles away from the person using the saw.

3. Sulfuric Acid and Sulfur Dioxide

The results of ion chromatography analysis of the front filters did not reveal concentrations of sulfate ions above the LOD of the method, estimated to be 2.0 µg/sample. Although sulfur trioxide is produced within the Kjeldahl Apparatus, any $SO_3$ that escapes from the apparatus would be oxidized rapidly to sulfur dioxide. Therefore, the results of the analysis of the treated filters were reported as $SO_2$. However, the results of sulfur dioxide monitoring are not reported here due to problems with the analytical method. The recommendations contained in this report address controlling potential exposures to sulfur dioxide through improved laboratory ventilation. Therefore, NIOSH investigators did not return to conduct additional sampling.

4. Laboratory Ventilation

Laboratory ventilation in Building 3 was found to be inadequate. The exhaust stack for the Kjeldahl apparatus terminates just beyond the fan on the roof, and then turns downward. Employees in this lab report that odors are noticeable in the laboratory under certain wind conditions. This may be due in part to the design of the exhaust stack. NFPA 45 specifies that, "Exhaust stacks should extend at least 7 feet above the roof." Most of the other hoods in the building do not function at all. Employees reported, and there is evidence (missing floor tiles, rusted laboratory cabinets) of roof leaks and standing water. The supports for the manifold in the Kjeldahl apparatus itself are rotted away, probably as a result of years of exposure to the process. The manifold is currently supported on cinder blocks.
Laboratory fume hoods in Building 4 have not been certified since 1982. The pesticide residue laboratory in Building 4 uses a large canopy hood as a containment device. This is scheduled to be replaced. However, both the micro lab and the pesticide laboratory are under positive pressure with regard to the rest of the building. This is not recommended, as any vapors, gases, or aerosols which evolved as the result of an accident would quickly spread throughout the building. If these laboratories must be maintained under positive pressure to protect their contents from contamination, airlocks which

exhaust to the building's exterior should be installed at the entrances to the laboratories. Alternatives which would allow these labs to be placed under negative pressure, such as filtration of air entering this laboratory, should be explored. The performance of the other hoods in this building should be evaluated. Due to the hazards associated with explosive perchlorates, the perchloric acid hood's design and installation should be evaluated with regard to the requirements in NFPA 45 for perchloric acid hoods.

Hoods in Building 6 are recertified annually. The two biological safety cabinets that were evaluated demonstrated good capture of smoke. The only eyewashes available in this building were eyewash bottles. The availability and use of personal protective equipment and work practices should be standardized based upon the requirements of a comprehensive biosafety program.

## VIII. CONCLUSIONS

The variety of organisms potentially encountered by lab workers in Building 6 may present a risk to their personal health. In many cases, these employees work with unknown biological material that should be treated with utmost caution, following the "universal precautions" specified for handling human blood and bodily fluids.[1] Occupational risk of exposure to infectious organisms can be minimized by establishing a comprehensive biological safety program, including organism-specific employee training.

After reviewing the analytical procedures involving animal blood and tissue performed in Building 3, it appears that the risk of infection is negligible because the procedures do not involve techniques that result in the generation of aerosols or the risk of needle sticks. Although the potential for exposure to infectious agents appears to be lower compared to Building 6, all laboratory workers would benefit from active involvement in a biosafety program.

The laboratory facilities in Building 3 are in extremely poor condition, and are clearly in need of extensive renovations. Air sampling conducted at the Kjeldahl apparatus did not document any overexposures to sulfuric acid, and was inconclusive regarding exposure measurements of sulfur dioxide. Renovations to the exhaust ventilation system should control any potential exposures to sulfur dioxide associated with the use of the Kjeldahl apparatus. The facilities in Building 4 are in need of review to determine whether they comply with recommended laboratory safety guidelines. Work practices and facilities in Building 6 should be reviewed periodically with regard to current recommended practices for biomedical laboratories.

None of the noise levels measured in the necropsy suite during the short survey period represent a risk to employees' hearing levels. The dosimetry documented levels of 81.2 dB(A) for the period. Even if the veterinarians were to continue these kinds of sawing operations on animals for an 8-hour period, they would not exceed any of the evaluation criteria for noise exposure. The dosimeters did, however, document noise levels up to 99 dB(A), which should be reduced. Additionally, the spectral measurements of the ventilation system in the necropsy suite revealed that noise produced by the system presents a situation where communication intelligibility will only be at minimal levels

of satisfaction. Noise in the veterinarian's office and in the electron microscopy laboratory did not approach levels associated with risk of hearing loss. However, spectral analysis of noise in these two locations indicate that the noise exceeded criteria for satisfactory communication for these types of settings.

Air sampling for particulates produced during animal necropsy did not document exposure to aerosols produced from saws used in these procedures. Recent studies have shown that there is a potential for the generation of aerosols during the use of surgical saws. Therefore, potential exposures to aerosolized biological material during necropsy should be included in the biological safety program for Building 6; and personnel involved in necropsy should utilize Safety Level Two precautions as described in reference 1.

## IX. RECOMMENDATIONS

### A. Medical

On the basis of information gathered during the walk-through, from the interviews, and from the questionnaire data, NIOSH investigators offer the following recommendations.

1. Implement a comprehensive safety program administered by a qualified designated individual. This recommendation is based upon the questionnaire finding that 98% of employees had not received standard biosafety training. In addition, since several employees, during the interview process, reported a reluctancy to approach management with complaints regarding workplace conditions, it is recommended that this safety program should also provide for a means of communication that allows employees to voice their concerns about workplace hazards and have those concerns addressed without a fear of recrimination.

2. Institute standardized infection control precautions on a building-wide basis for each of the three buildings. The walk-through inspection revealed the variety of tasks performed, and organisms encountered, by an individual worker. Building-wide standardization will avoid confusion resulting when personnel switch back and forth among different levels of precaution. Based upon a review of the potential agents encountered and the tasks performed, these standardized precautions should include those outlined for Safety Level Two in the Centers for Disease Control handbook on Biosafety in Microbiological and Biomedical Laboratories (see appendix 1).

3. Provide adequate personal locker space that is separate from the labs so that employees can keep personal items, such as food, purses, medications, and street clothing separated from potential workplace exposures. At present there is an obvious shortage of secure lockers and this may account for the fact that over 80% of employees keep personal belongings in the laboratory work area.

4. Ensure that lab coats or uniforms are readily available, especially for the 40% of laboratory workers who do not routinely wear them at present. Discourage

the home laundering of work clothes or the wearing of street clothes while working.

5. As relayed in previous correspondence and during our closing conversation, there is a need for a responsible safety officer who will institute and supervise on-the-job training for employees involved in handling biological samples.

B. Noise

Because of the noise results found during the survey, NIOSH investigators offer the following recommendations to the Ohio Department of Agriculture.

1. The use of hearing protection devices (HPDs) during sawing operations should be continued because of documented noise exposures of 99 dB(A) resulting from the saws. Any type of HPD should be sufficient to attenuate the noise levels found in the laboratory. Perhaps a semi-aural device which can be worn around the neck when not in place would be more convenient to the veterinarians. The semi-aural devices are commonly seen at airports on employees who meet the aircraft at the gate areas. Any local safety supply store should be able to furnish the Department of Agriculture with a list of companies who produce this kind of HPD.

2. The rattling of the skull bone on the metal table can be eliminated by putting a wooden butcher block in the necropsy lab for sawing this type of material. A sealed butcher block can be easily disinfected so that infection control should not be an issue with the use of a block.

3. A ventilation consultant should be hired to evaluate the ventilation system and offer suggestions for noise reduction. While the noise emitted by the system does not pose a hazard to the veterinarians' hearing ability, it does present problems for communications between individuals in the laboratory. The categorization of NC curves stipulates criteria between NC-40 to NC-50 for laboratory work spaces where moderately fair listening conditions are warranted.[39]

4. Noise in the veterinarian's office could be controlled through the installation of a noise-reducing diffuser in place of the air-supply diffuser currently installed in the office.

5. Enclosure or relocation of the vacuum pump outside of the electron microscopy laboratory would reduce the noise in that location.

C. Industrial Hygiene

Based upon the results of the walk-through, the following recommendations are offered to ODA:

1. If the pesticide and microbiology laboratories in Building 4 must be maintained under positive pressure to protect their contents from contamination, airlocks which exhaust to the building's exterior should be

installed at the entrances to the laboratories. Alternatives which would allow these labs to be placed under negative pressure, such as filtration of air entering these laboratories, should be explored.

2. The performance of the other hoods in this building should be evaluated.

3. Due to the hazards associated with explosive perchlorates, the perchloric acid hood's design and installation should be evaluated with regard to the requirements in NFPA 45 for perchloric acid hoods.

4. Damaged ductwork in Buildings 3 and 4 suspected of containing asbestos should be repaired immediately. Asbestos containing debris in the cellar under Building 3 should be cleaned up. These procedures should be performed by qualified individuals.

5. Building 3 is in need of extensive renovations in order to support current ODA analytical laboratory responsibilities.

6. Personnel performing necropsies should be included in the biosafety program and utilize suitable personal protective equipment.

7. The eyewash bottles in Building 6 should be replaced by eyewashes capable of providing at least 15 minutes of continuous flow. Guidelines for the selection, placement, and periodic inspection of eyewashes are found in ANSI Z358.1-1981.

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3. Local 4550, Ohio Civil Service Employees Association
4. OSHA, Region V
5. NIOSH

For the purpose of informing affected employees, 42 CFR 85.11 requires the employer to post copies of this report in a prominent place accessible to the employees for a period of 30 calendar days.

**Table 1**
Results of questionnaire assessing work habits and
safety knowledge of 55 laboratory employees.
Ohio Department of Agriculture, Reynoldsburg, OH
November 25-26, 1991 and February 7, 1992
HETA 91-287

| **Work Practice/Knowledge** | **% of employees** |
|---|---|
| Change clothes when arrive at work | 16 |
| Usually wear a lab coat or uniform over street clothes* | 60.5 |
| Keep coat or jacket in the lab | 42 |
| Keep personal belongings such as purse in the lab | 81 |
| Keep lunch in the lab | 9 |
| Wear lab coat while eating lunch | 33 |
| Always wash hands before eating lunch | 95 |
| Wash hands in lab sink | 83 |
| Wear gloves at any point during the work day | 91 |
| Have ready access to disposable gloves | 100 |
| Have ready access to disposable masks | 95 |
| Wear masks at any point during the work day* | 54 |
| Ever wear eye protection* | 33 |
| Use at least some rebottled products | 52 |
| Think that majority of rebottled products aren't properly labeled | 37 |
| Disinfect their work surfaces <2 times/day rather than after every procedure | 41.5 |
| EVER heard of Biosafety Classification of Disease Organisms* | 35 |
| Received ANY training on Biosafety levels while working at the Reynoldsburg Labs* | 2 |

* Calculation excludes strictly clerical workers.

TABLE 2

Sawing Activities in the Necropsy Laboratory
All noise levels are reported in dB(A)

| Body Section | Saw | Time (mm:ss) | $L_{eq}$ | High | Low |
|---|---|---|---|---|---|
| Spinal Column (pig) | Wellsaw | 00:12 | 88.7 | 93.3 | 73.0 |
| Spinal Column (pig) | Wellsaw | 00:16 | 93.1 | 96.0 | 77.5 |
| Skull (pig) | Stryker | 01:37 | 89.0 | 93.8 | 85.0 |
| Spinal Column (cow) | Wellsaw | 01:15 | 94.3 | 97.5 | 76.8 |
| Skull (cow): midline split | Wellsaw | 00:33 | 98.1 | 100.4 | 80.8 |
| Skull (cow): midline split | Wellsaw | 00:14 | 93.4 | 96.0 | 69.3 |
| Spinal Column (cow) | Wellsaw | 00:59 | 96.8 | 100.8 | 76.8 |

Appendix 1

Biosafety in Microbiological and Biomedical Laboratories; 2nd edition May 1988. HHS Publication No. (CDC) 88-8395.

Standard Microbiological Practices

1) Access to the laboratory is limited or restricted by the laboratory director when work with infectious agents is in progress.

2) Work surfaces are decontaminated at least once a day and after any spill of viable material.

3) All infectious liquid or solid wastes are decontaminated before disposal.

4) Mechanical pipetting devices are used; mouth pipetting is prohibited.

5) Eating, drinking, smoking, and applying cosmetics are not permitted in the work area. Food may be stored in cabinets or refrigerators designated for this purpose only. Food storage cabinets or refrigerators should be located outside of the work area.

6) Persons wash their hands after handling infectious materials and animals and when they leave the laboratory.

7) All procedures are performed carefully to avoid the creation of aerosols.

Special Practices

1) Contaminated materials that are to be decontaminated at a site away from the laboratory are placed in a durable leak-proof container which is closed before being removed from the laboratory.

2) The laboratory director limits access to the laboratory. In general, any persons who are at increased risk of acquiring infection or for whom infection may be unusually hazardous are not allowed in the laboratory or animal rooms. The director has the final responsibility for assessing each circumstance and determining who may enter or work in the laboratory.

3) The laboratory director establishes policies and procedures whereby only persons who have been advised of the potential hazard and meet any entry requirements (e.g., immunization) enter the laboratory or animal rooms.

4) When the infectious agent(s) in use in the laboratory require special provisions for entry (e.g., vaccination) a hazard warning sign, incorporating the universal biohazard symbol, is posted on the access door to the laboratory work area. The hazard warning sign identifies the infectious agent, lists the names and telephone number of the laboratory director or other responsible person(s), and indicates the special requirement(s) for entering the laboratory.

5) An insect or rodent control program is in effect.

6) Laboratory coats, gowns, smocks, or uniforms are worn while in the laboratory. Before leaving the laboratory for nonlaboratory area (e.g., cafeteria, library, administrative offices), this protective clothing is removed and left in the laboratory or covered with a clean coat not worn in the laboratory.

7) Animals not involved in the work being performed are not allowed in the laboratory.

8) Special care is taken to avoid skin contamination with infectious materials; gloves should be worn when handling infectious animals or when contact with infectious materials is unavoidable.

9) All wastes from laboratories and animal rooms are appropriately decontaminated before disposal.

10) Spills and accidents which result in overt exposures to infectious materials are immediately reported to the laboratory director. Medical evaluation, surveillance, and treatment are provided as appropriate and written records are maintained.

11) When appropriate,considering the agent(s) handled, base-line serum samples for laboratory and other at-risk personnel are collected and stored. Additional serum specimens may be collected periodically, depending on the agents handled or the function of the facility.

12) A biosafety manual is prepared or adopted. Personnel are advised of special hazards and are required to read instructions on practices and procedures and to follow them.

Figure 1

Ohio Department of Agriculture - Necropsy Laboratory
Veterinarian #1
HETA 91-287
February 7, 1992

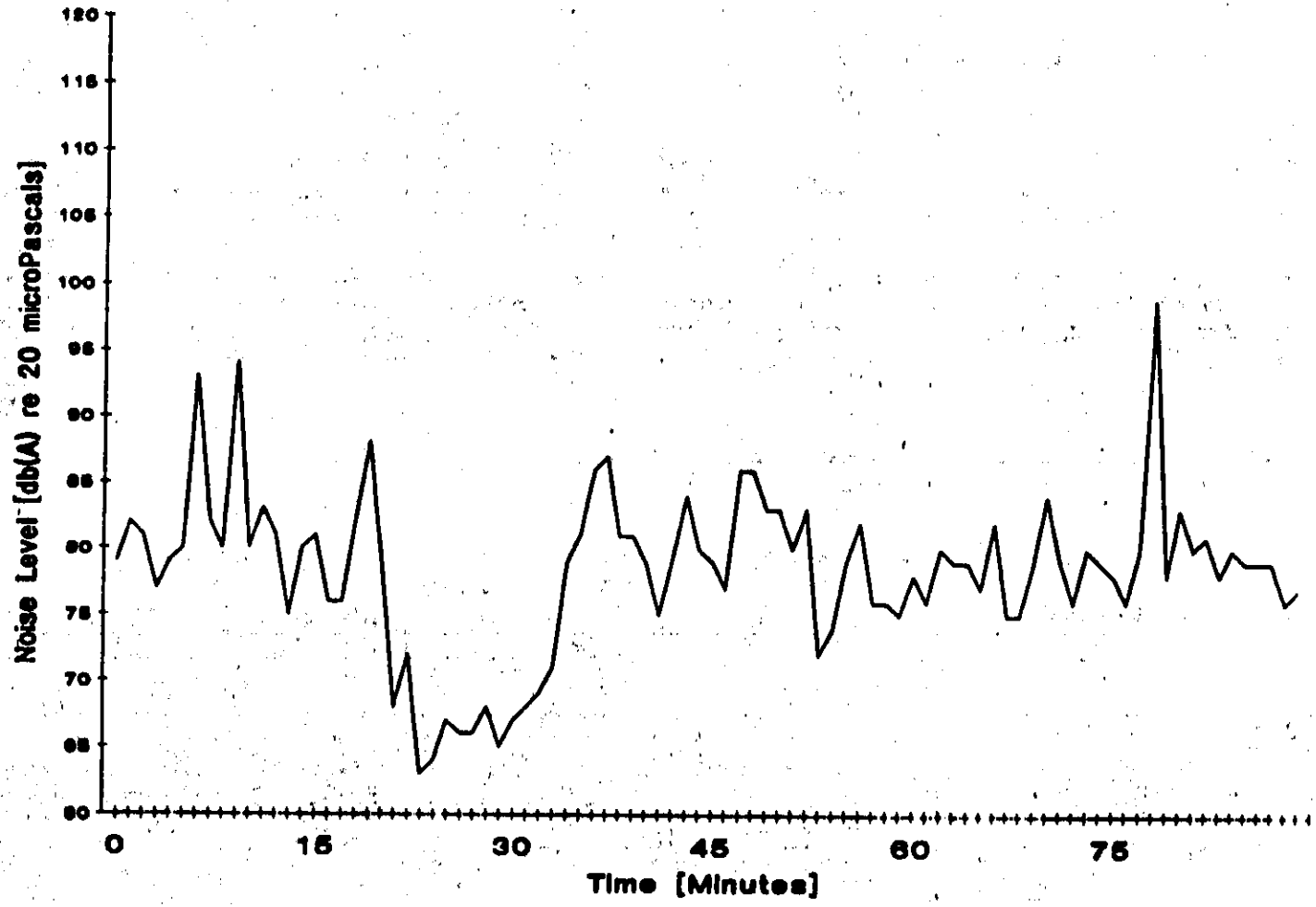
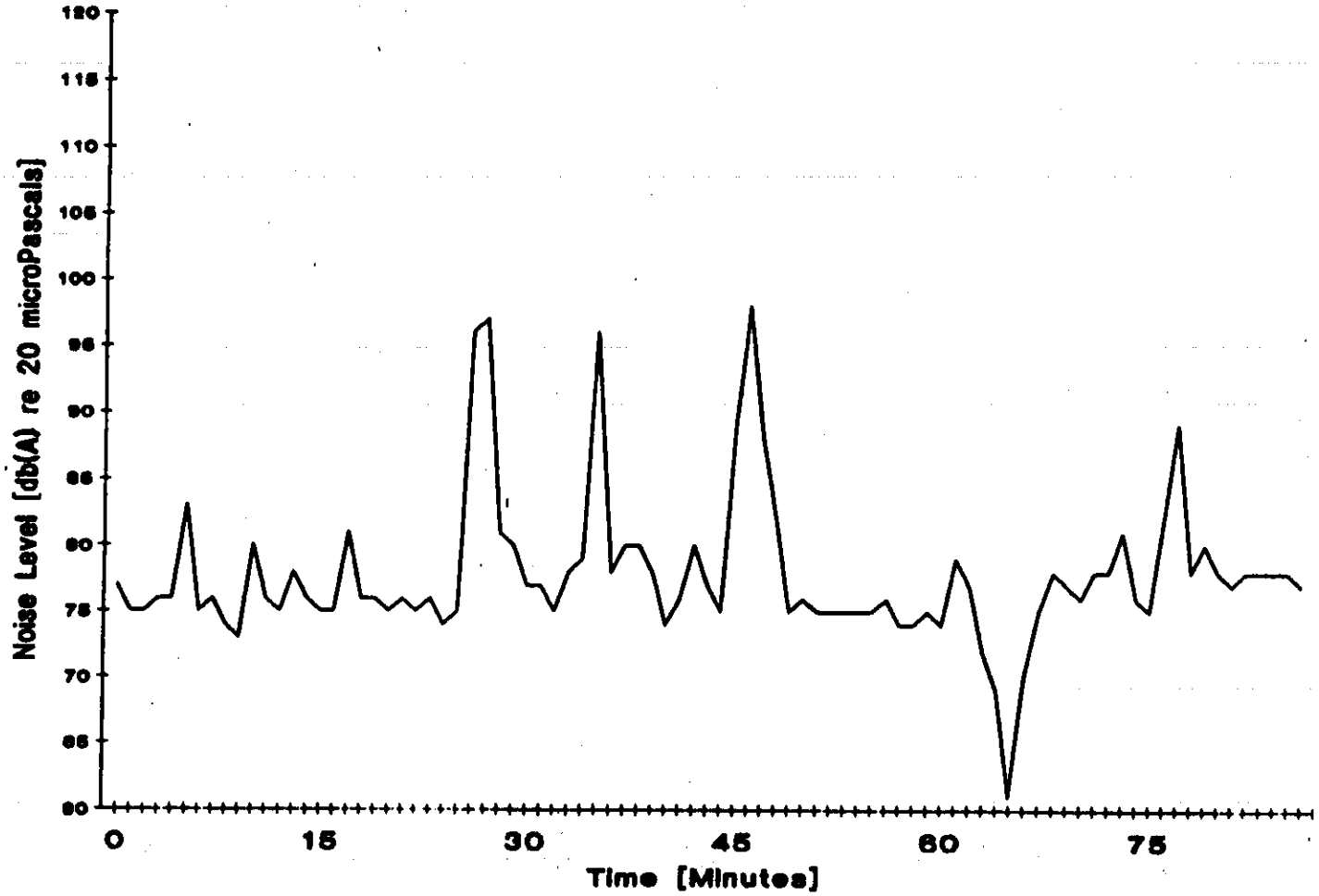


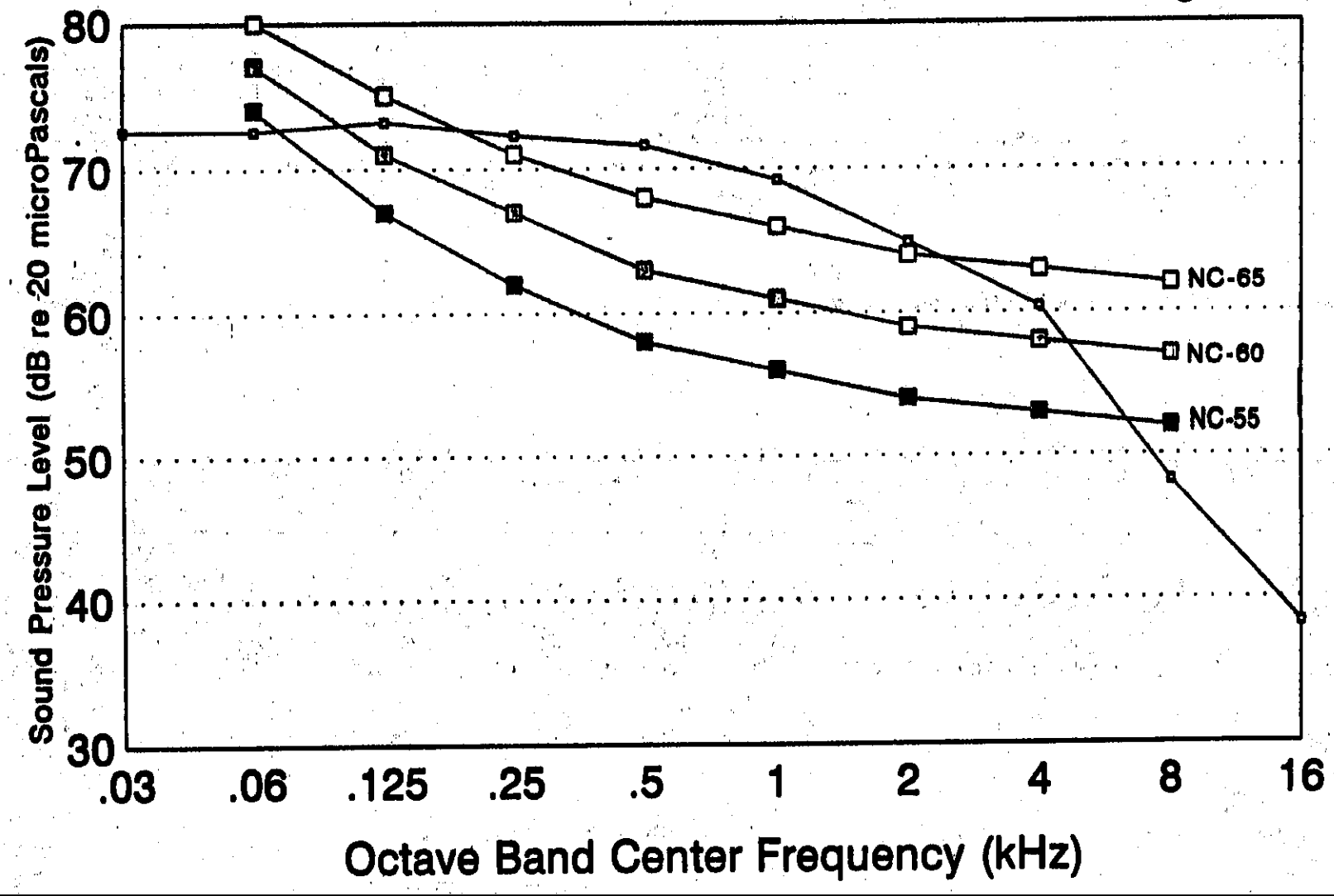
Figure 2

**Ohio Department of Agriculture - Necropsy Laboratory**
**Veterinarian #2**
**HETA 91-287**
**February 7, 1992**



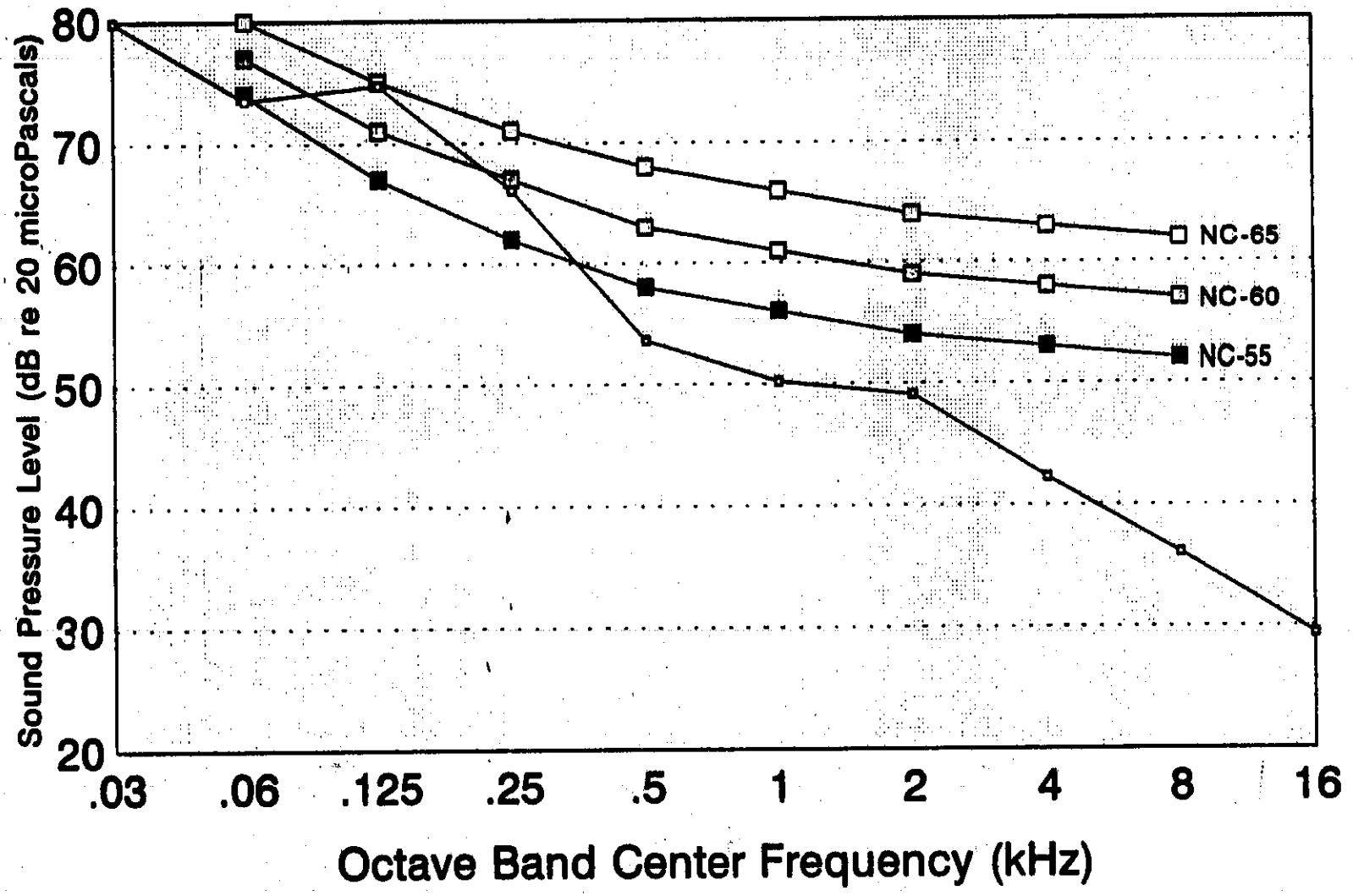
# Ohio Department of Agriculture
# Necropsy Lab Ventilation System
# Reynoldsburg, Ohio

Figure 3



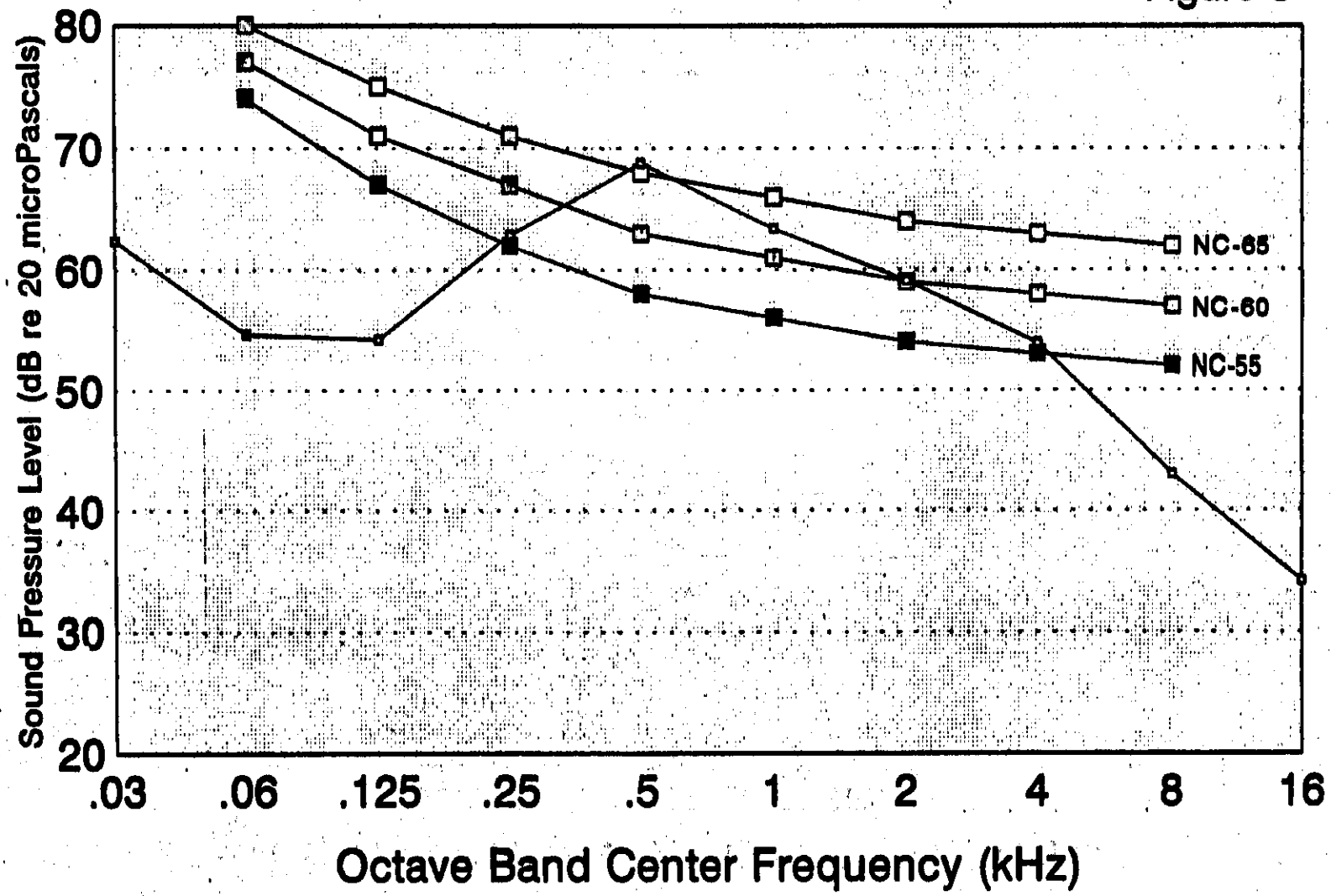
# Ohio Department of Agriculture
# Veterinarian's Office
# Reynoldsburg, Ohio

Figure 4



# Ohio Department of Agriculture
# Electron Microscopy Laboratory
# Reynoldsburg, Ohio

Figure 5

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